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THE PATHOLOGICAL ANATOMY OF THE CEREBRO-SPINAL AXIS OF A CASE OF CHRONIC MYELITIS OF NINETEEN YEARS' STANDING.

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THE following case of chronic myelitis offers some points of interest, both by its long duration, and by the unusual manner in which the inflammatory process in the cord was produced. Being desirous of accurately knowing whether, in the long course of nineteen years, special pathological changes differing from those which I had previously observed in the spinal cord of acute cases of myelitis, might have taken place in this case, I subjected the cord, medulla oblongata, and pons Varolii to a very close and careful microscopical examination, the results of which will form the chief subject of this paper.

The early history of this case is, of course, based upon the patient's own account, though it appears to be tolerably correct on account of its having been repeatedly told by the patient to different physicians, under whose care he was, at different periods, in the wards of the Charity Hospital, and who recorded it in their respective ward-books. It is as follows:

Thomas McGinnis, a native of Ireland, and at his death fifty-one years old, received, in 1863, in an engagement at Chalk Bluff, Arkansas, during the American Civil War, a gunshot wound through the back of the neck. In the production of this wound the ball entered the right side of the neck, in the region between the fifth and sixth cervical vertebræ, and, passing closely behind the vertebral column, issued at a corresponding point on the opposite side. After being shot he fell to the ground, and for some time remained unconscious; but, on recovering his senses, he found himself completely paralyzed in both the upper and lower extremities. After a short time, however, the paralysis disappeared from the latter, leaving only motor paralysis of the arms, to be followed soon afterward by a marked hyperæsthesia of the neck and both upper extremities, accompanied by acute pains. The grade of hyperæsthesia was such that the slightest touch would cause excruciating pain. Nevertheless, in a short time, the hyperæsthesia disappeared, to be replaced by an anæsthesia which was more marked at one time than at another. In the paralyzed members total suppression of reflex action soon supervened, followed after some time by violent jerks and cramps with temporary rigidity of the muscles involved. About a year later contractures of both arms commenced to take place. At first these contractures maintained the paralyzed limbs in a state of forced extension, which condition after some time changed to one of forced flexion.

Thus the condition of the patient—judging from some accounts received after his death—remained, with perhaps little change for the better or the worse, the same until 1879, when he first attracted attention in the wards of the Charity Hospital; though he may have been, as it frequently occurs in these kinds of cases, an inmate of this institution at a previous time. When admitted, in 1879, to the wards of the hospital, the cicatrices left from the gunshot wound on the sides of the neck of the patient were still distinctly seen. He had fair use of his lower limbs; for, notwithstanding his left foot being drawn in such a position as to assume the appearance of "talipes equinus," he was able to walk. He began now to experience pains and formication in his lower limbs. Sometimes, when rising from his bed in the morning, his legs would fail him and he would fall heavily upon the floor. Hyperæsthesia of both inferior extremities now set in, which seemed to be more marked in the left limb than in the right. About this time several months had elapsed and the patient, leaving the hospital, was lost sight of until May, 1881, when he was again admitted to the wards of the institution. His left arm was then contracted against his chest, the contraction appearing sometimes spasmodic. Both hands were closed by a tonic and permanent contraction of all the fingers, which, from the account of the patient had slowly but steadily taken place. The muscles of both hands and arms were much atrophied. There was slight hyperæsthesia of the left upper extremity, but retarded transmission of sensation; the sensibility of the right upper extremity was normal. Loss of motion was complete in both upper limbs, the patient being unable to feed himself, while he had still such a fair use of his lower limbs as to be able to walk even with his eyes closed. The left leg appeared to be stiff, as he dragged it along in walking, and, judging from the clearness of his mind, his brain was apparently unaffected.

In this condition the patient left the hospital during the same month, but returned soon after on June 7th, to be treated for an attack of diarrhœa, to which he had always been subject. Remaining then until September 14th, of the same year, he deserted the institution and went to a boarding-house on Front Levee Street, kept by a Mr. W——, where he remained until August 14, 1882, when he was again brought to the hospital in a state of complete paralysis and unconsciousness, in which condition he died some hours afterward. Upon inquiry it was ascertained that during the greater part of the time the patient lived with the above Mr. W——, he was perfectly helpless, scarcely able to stand, and totally unable to walk, and that during the last six months he had no control over his bowels and bladder, passing his fæces and urine involuntarily in bed while asleep. Mr. W—— furthermore stated, that ever since the reception of the injury the patient had been unable to perform any kind of work for a living, but had to rely solely on his friends for support.

The autopsy, performed a few hours after death, was confined to the removal of the brain and spinal cord. As regards the brain I may state, that though the unconsciousness in which the patient had been brought to the hospital, together with the accompanying clinical symptoms, had been supposed to depend upon a cerebral hemorrhage, not the slightest effusion of blood could be discovered upon or in the substance of the brain. The only condition found, and to which the patient's state of unconsciousness might perhaps have been attributed, was an abnormal congestion of the larger veins of the pia mater. In all other respects the macroscopical appearance of the whole brain was perfectly normal, inducing me, though to my subsequent regret, to confine my microscopical examinations to the spinal cord, medulla, and pons.

Whilst removing the spinal cord the cicatrices in the skin of the neck, indicating the entrance and exit of the ball, were still observed. Besides these, with the exception of a certain toughness of the tissues surrounding the vertebral column, no other traces of the former injury of the neck, such as a fracture of the vertebræ, etc., could be found. The dura mater was found slightly thickened in the vicinity of the fifth and sixth cervical vertebræ, while the rest presented a normal appearance. The pia mater, on the contrary, though showing no trace of a forcible injury, appeared slightly thickened throughout, while its vessels, especially in the cervical and upper dorsal regions, were completely filled with blood. The spinal cord itself appeared slightly diminished in bulk. In the cervical region, particularly in the neighborhood of the former passage of the ball, it was found to have decreased in its antero-posterior diameter, and, in consequence, appeared flattened. Its consistency was rather less than normal, especially in the cervical region, where it was found soft and elastic when pressed between the fingers. This feeling of softness was owing to the posterior commissure and its neighboring parts of the gray substance having undergone the degeneration to be described hereafter. A number of transverse sections, made through the fresh cord, revealed, that in this region the parts just named were softened to such a degree, as to have given rise to a tubular cavity in the substance of the cord. Upon the surface of the sections, made throughout the whole cord, it was observed that certain portions of the white substance presented a yellowish-gray appearance. Thus in the cervical region, the gray color was principally confined to the posterior columns, to the posterior part of the left lateral column, and to the periphery of the rest of the white substance. In the anterior, and in the rest of the lateral, columns, however, gray spots were also observed here and there, showing that the degeneration was not strictly confined to definite portions of the cord, such as is generally met with in the so-called ascending and descending degeneration of this part of the cerebro-spinal axis. This discoloration was observed throughout the whole cord, though diminishing in degree in the dorsal, and still more in the lumbar, regions.

Upon the surface of a section made through the medulla oblongata the yellowish-gray discoloration was observed not to be distinctly limited to certain localities, but rather appeared diffused over the whole surface, the gray substance of which appeared abnormally pale; the same appearance was observed upon a section made through the pons Varolii.

After the above macroscopical examination the parts concerned were hardened in Mueller's fluid and then kept in alcohol for the subsequent microscopical studies. These were chiefly made from a considerable number of thin sections taken from different parts of the several regions of the spinal cord, medulla, and pons. While a part of these sections were stained with picro-carmine and hematoxylin, and mounted in Canada balsam, others were left unstained, to be mounted and examined in glycerine. A considerable part of the studies, however, was pursued on teased preparations made from these sections.

Let us now consider the results obtained from these microscopical studies, and begin with stating, that the prominent pathological phenomena observed in this case were: 1st, a congestion and degeneration of almost all the blood-vessels; 2d, a fibrinous exudate effused into the larger and smaller septa of the affected parts of the cord, and giving rise by its pressure upon the nervous elements of the white and gray substance to 3d, atrophy of the nerve-fibres; and 4th, degeneration of the ganglionic bodies or cells.

The discoloration observed by the naked eye in the white substance of the sections made of the fresh cord, as above mentioned, was chiefly depending upon the presence of this fibrinous exudate, which consisted of very minute granules. In very thin unstained sections, or in teased portions of such, the granules were arranged in minute groups presenting the appearance of small granular bodies. A similar arrangement I had observed, a number of years ago, in the granular substance of the gray matter of the cerebro-spinal axis; and it may also be observed on the granules of the protoplasm of many cells, and even on those of pure fibrin. In fact, the fibrinous exudate under consideration resembled in every respect that met with in cerebro-spinal meningitis. It was chiefly found surrounding the larger or smaller blood-vessels of the affected parts, having inundated the larger and, even more so, the smaller septa (fig. 2). Nor was it confined to the white substance, but was equally met with in the degenerated portions of the gray. Like other neo-plastic productions, it very readily absorbed the carmine, a circumstance which greatly facilitated its detection in the stained sections mounted in balsam.

Almost all the blood-vessels were found diseased or degenerated; there were very few, if any, of them observed in a perfectly normal condition; those, as yet not completely degenerated, were congested with blood corpuscles. The least affected blood-vessels were perhaps those of the pia mater; but even among these there were hardly any met with perfectly normal. Thus, while in most of them the adventitia appeared thickened, the muscular fibre-cells of the muscular layer could only be detected with great difficulty. In those instances, where these fibre-cells could be made out, it was only their transverse sections that were seen in the walls of the vessels, whilst in no instance could they be detected with their long diameter across the vessels. In many of these vessels the protoplasm of the cells of their adventitia had much increased (fig. 1).

In the spinal cord, medulla oblongata, and pons scarcely any vessel was observed in a normal condition. Almost all of them were surrounded by a thinner or thicker layer of the granular exudate (figs. 3 to 7), which, however, not only surrounded the vessels, but could be, moreover, distinctly seen in their interior, where it appeared to fill up the interspaces left by the blood corpuscles (figs. 4, 6, and 7). The walls of all the arterioles, venules, and capillaries appeared pale and granular, their outlines were generally very faint, showing that the vessels were undergoing a slow degenerating and atrophying process. Many of these minute vessels had already become completely atrophied, appearing, by the disappearance of their lumen, like pale granular strings. Others presented dilatations or varicosities in their course, filled up with granular matter, while beyond the varicosity their lumen had disappeared and their walls had atrophied into a string (fig. 5). The degeneration and atrophy of the minute blood-vessels were equally observed throughout the whole spinal cord, medulla, and pons; though they were, perhaps, more general in the cervical portion of the cord, where the exudate was present in greater abundance than in the other parts.

It has already been mentioned that the yellowish-gray portions of the cord, seen by the naked eye upon its fresh sections, represented those parts where the exudate was most abundantly effused, and where, in consequence, the atrophy of the nerve-fibres concerned had reached the highest degree (fig. 2). The changes which the nerve-fibres had undergone in these places represented a simple atrophy, caused by the pressure of the exudate. The gradual decrease of the nerve-fibres in their diameters appears to be caused, in the beginning of the atrophying process, by a diminution of their nerve-medulla, so that as soon as this substance has completely disappeared, nothing remains but the axis-cylinders surrounded by the external sheaths (Schwann) of the nerve-fibres; and as the morbid process still further proceeds, these parts of the nerve-fibres, also, become paler and paler, until finally they may entirely disappear from sight, such as is observed in very thin transverse sections of the spinal cord (fig. 2).

But it must not be imagined that this atrophy of the nerve-fibres takes place evenly throughout their whole length. On the contrary, while in one part of a fibre the whole medullary sheath may be still intact, it may have completely disappeared in another, and it is thus that the nerve-fibre, before becoming atrophied throughout its course, shows itself in a more or less varicose form. This condition of the nerve-fibres is distinctly observed in very thin longitudinal sections of the diseased spinal cord. In such sections it is seen, that while some of the remaining nerve-fibres present a varicose appearance, nothing is left of others but their axis-cylinders; or even these may have entirely disappeared (figure 1). In transverse sections, on the other hand, a great difference in the diameter of the nerve-fibres is observed, which, however, is not to be compared with the difference existing in the diameters of the fibres of a tract in a normal cord, but to the fact that in the diseased cord in question the larger sections of fibres represent those of varicosities, while the smaller ones have passed through axis-cylinders surrounded only by the tubular sheaths. It remains to be remarked that, with a few exceptions, the axis-cylinders of the nerve-fibres in this case were not swollen, such as I have observed in cases of traumatic injuries of the spinal cord, but on the contrary had generally preserved their respective normal diameters.

In the gray substance of the cervical portion of the cord, especially in the vicinity of the posterior commissure, the exudate had also been abundantly effused, and had given rise not only to the degeneration and final disappearance of the ganglionic bodies, but to the final breaking down of this portion of the gray columns, causing the tubular cavity mentioned above. Thus, almost all the ganglionic bodies of the anterior horns of this region had disappeared; only a few belonging to the outer or lateral group had remained.

Although the fibrinous exudate had been effused into the septa of the whole spinal cord, it was much diminished in quantity in the dorsal and lumbar regions; in consequence, the atrophy of the nerve-fibres, and the complete degeneration of the ganglionic bodies, also, had taken place only to a small extent in these regions. In teased preparations, however, the exudate was still found to surround a great number of blood-vessels, as already mentioned, even in the conus medullaris. The same conditions were observed in the medulla oblongata and in the pons Varolii. Embedded in the exudate were observed a number of small nuclei and cells, which very probably represented colorless blood corpuscles, escaped from the vessels with the fibrinous effusion.

The most interesting phenomenon observed in this case, however, was the peculiar degeneration of the ganglionic bodies, especially of those distributed throughout the medulla oblongata and pons Varolii. These bodies presented different appearances according to the degree of degeneration they had undergone. Those which showed the least changes in their appearances, of course, were met with in the lumbar and in the middle and lower third of the dorsal regions. But even here the appearance of a great number of these bodies was abnormal; for in many of them the nucleus had either entirely disappeared, leaving, however, the nucleolus behind, or it appeared indistinct with a peculiar refractive lustre. In others, again, the pigment granules appeared increased in number; or the body itself was rounded off and without processes. In the cervical region the greater part of ganglionic bodies had altogether disappeared, as already mentioned, while those remaining presented the appearances just described, or were even observed in a higher degree of degeneration. The greatest changes in the ganglionic bodies, however, were observed in the medulla oblongata and pons Varolii, the very parts in which, from my macroscopical examination, I had least expected them. The nature of the degenerative process which these bodies had been undergoing appeared to me peculiar, and differing from those morbid processes generally observed in the elements of other organs. I have carefully studied it on a large number of ganglionic bodies, isolated from the other nervous elements by teasing thin sections taken from the spinal marrow, medulla oblongata, and pons Varolii with finely pointed needles, and shall now describe the appearances which these bodies present in the different stages or degrees of their degeneration.

In examining very thin stained sections, taken from the most degenerated part of the spinal marrow in the cervical region and mounted in Canada balsam, I observed a number of smaller or larger, clear, and slightly refractive spaces;

they were also met with in stained sections of the medulla and pons, mounted in balsam, where they differed from those observed in the spinal marrow by being more numerous, and many of them also larger. But as, on account of the great transparency of the Canada balsam, the examination of the exact details of the histological elements of a tissue mounted in this medium, is rendered very unsatisfactory, I turned my attention to the examination of the thin unstained sections, which I had mounted in glycerine, and in which I found the outlines of the above-mentioned clear spaces better defined. Although I had been at first inclined to regard these bodies as representing globules or accumulations of fat, the products of a fatty degeneration of the nervous elements concerned, I found now, that though they exhibited some of the optical characters of fat, they were nevertheless wanting in the high refraction of light characteristic to true fat-globules, and when I proceeded to isolate these bodies by teasing very thin sections, I found them to represent ganglionic bodies, or connective-tissue cells, which had undergone a peculiar fatty metamorphosis. The observation which I made, of their remaining unaffected by boiling the sections in ether, inclined me to think, at one time, that they might be amyloid in their nature. Accordingly I applied to them the known tests for the so-called amyloid substance, such as iodine, sulphuric acid, and methyl violet, to which they, however, completely failed to respond; for, the application of iodine, either alone, or with the addition of sulphuric acid, simply stained them yellow, while they were colored blue by methyl-violet. I regret to have neglected the microscopical examination and the application of these tests to the elements under consideration in their fresh condition, that is, before the spinal cord, medulla, and pons were put in Mueller's fluid for preservation, as I was engaged in some other subject at the time when the autopsy was made. My subsequent examinations of these bodies, however, showed me conclusively, as will be seen directly, that the degeneration in this case was not amyloid in its nature. Besides, the deposition of the morbid product into the walls of the blood-vessels, which in true amyloid degeneration is so prominent a trait, was entirely wanting in our case. On the contrary, the pathological process taking place here was in fact a peculiar, slow, fatty metamorphosis, leading, in many of the anatomical elements affected, to a crystallization of the morbid product. The principal elements affected were the ganglionic bodies of the gray substance, while the degenerated bodies found among the nerve-fibres of the white substance very probably represented the nuclei, lodged in the sheath of Schwann, of the dark-bordered nerve-fibres, as well as the minute cells of the neuroglia, of the adventitia of the vessels, and of the fibrinous exudate. In the spinal marrow the most of these bodies were small in diameter (figures 1 and 2), for which reason I regarded them as representing the degenerated minute cells just named. In transverse sections the most of them are round in form, while in longitudinal sections they appear more oval; this difference of form in the different sections is owing to the general oblong form of the nuclei of the nerve-fibres and of the adventitia of the vessels. There remains no doubt about the origin of these bodies, lodged in the adventitia of the blood-vessels, and in the exudate surrounding them, as seen in figures 1, 3, and 7. There were also a number of larger ones, representing degenerated ganglionic bodies, met with in the anterior horns of the spinal cord, though comparatively not as many as in the medulla oblongata and pons Varolii.

In studying the difference existing in the appearance of a number of these degenerated ganglionic bodies, we are to a certain extent enabled to form some idea of the peculiar morbid process and of its progressive phases, to which these bodies have fallen a prey. The ordinary process of fatty degeneration consists, as we know, in a gradual metamorphosis of the protoplasm of the cells or other histological elements into fat. The latter, at first, appears in the protoplasm of the cells in the form of very minute fat-globules, which eventually fuse with one another to form larger ones. In the degenerative process of the ganglionic bodies under discussion, however, no minute fat-globules make their appearance; on the contrary, the normal granules of the ganglionic body gradually lose in definition, the whole body presenting the appearance of a turbid dull lustre, while its outlines appear slightly darker than they normally are. The outlines of the nucleus in the interior of the body are rendered faint and indistinct, to eventually disappear altogether, while the nucleolus appears more prominent and holds its place until the degeneration has considerably advanced (figures 8, *a* and *b*). Judging, therefore, from the appearance which these bodies present in the first stage of their degeneration, I am inclined to regard the degenerative process in this case as commencing in the so-called parenchymatous inflammation, or cloudy swelling of Virchow. As the process advances, the granules, nucleus, and nucleolus disappear entirely, and the ganglionic body, while losing its shape, changes its optical characters by becoming more refractive (fig. 8, *c*, and figs. 9, 11, and 12); though, at this stage of the metamorphosis, many of the bodies still present a faintly granular appearance. As already mentioned, they remain unaffected by being boiled in ether, nor are they affected by a 30-per-cent. solution of caustic potash; the only effect which this reagent produces on the section containing them, is to render the tissue much clearer for their study.

In the medulla oblongata, it was especially the ganglionic bodies of the substantia reticularis, but also some of the nuclei of the olivary bodies, that were found to undergo the degeneration here described (figs. 8, 9, 10, and 11). In the pons Varolii the degenerating bodies were likewise met with in the substantia reticularis, but also in the gray substance found in the interspaces of the bundles of transverse fibres, connecting the hemispheres of the cerebellum (fig. 12). Even in the midst of the latter, some of these bodies, apparently connected to nerve-fibres (fig. 12, *e*), were observed to be lodged; but whether they represented in this place degenerated ganglionic bodies or the cells of the external sheath of dark-bordered nerve-fibres, I could not satisfactorily ascertain. In the pons Varolii, a number of smaller or larger crystalline masses, some of which still showed the shape of the degenerated bodies in question, were met with; they were highly refractive in their appearance, and when examined on the dark field of the polariscope, were found to polarize the light in a brilliant manner, showing the complementary colors yellow, red, and blue (fig. 13). These masses were principally found lodged between the nerve-fibres of the transverse bundles of the pons, or upon them; some of them were quite long, though transversely broken in several pieces; these were apparently formed from several degenerated and crystallized ganglionic bodies.

Judging from the great number of these degenerated ganglionic bodies, I presume that the degenerative process had ascended still higher up into the brain, through the crura cerebri, even to the larger ganglions of the organ; and it appears to me very probable that the smaller blood-vessels of the rest of the brain were likewise diseased. I cannot but again regret that I neglected the preservation and examination of the rest of this organ. The negligence, however, which I committed in this case, again shows how little we can rely on a mere macroscopical examination in diseases of the cerebro-spinal axis.

I abstain from any remarks on the general pathology of the case, leaving it to the reader to draw his own conclusions from its rather meagre history. But as regards its ætiology we may judge from the absence of any trace of forcible injury to the spinal cord, and also from the symptoms appearing directly after the reception of the gunshot wound, that the inciting cause of the myelitis may be found in the concussion to which the spinal cord was subjected by the passage of the ball through the muscles of the back of the neck.

Explanation of the Illustrations.

Fig. 1.—Transverse vertical section of the spinal cord in its cervical region, showing the exudate and the atrophied nerve-fibres. *a*, pia mater, with one of its blood-vessels, in the adventitia of which a degenerating cell is observed; *b*, spinal cord, showing the atrophying varicose nerve-fibres embedded in the fibrinous exudate. Some of the smaller degenerated bodies described in the text are also seen distributed throughout the section.

Fig. 2.—Horizontal section of the spinal cord in the cervical region, showing the sections of the atrophying nerve-fibres and axis-cylinders embedded in the fibrinous exudate, which is seen confined to the cord. *a*, pia mater : *b*, portion of spinal cord divided by two septa ; at its periphery the fibrillæ of the layer of neuroglia surrounding the cord may be observed.

Fig. 3.—Represents a blood-vessel from the lumbar portion of the spinal cord, with its adventitia thickened, and surrounded by fibrinous exudate, in which some of the degenerated cells may be seen. The vessel is filled with blood corpuscles, which, by mutual pressure, have assumed an hexagonal form.

Fig. 4.—Arteriole, taken from the pons Varolii (basis), and containing blood corpuscles and granular matter (fibrin) ; it is also surrounded by the fibrinous exudate.

Fig. 5.—Degenerated capillaries with varicosity.

Fig. 6.—Capillary vessels, surrounded by portions of the exudate.

Fig. 7.—Minute artery, surrounded by the exudate, containing a degenerated cell ; in the walls of the vessel some of the muscular fibre-cells are still seen in their transverse sections.

Fig. 8.—Ganglionic bodies, of the medulla oblongata, showing

their appearance in the different stages of the degenerative process.

Fig. 9.—Degenerated ganglionic bodies, from a section of medulla oblongata boiled in ether.

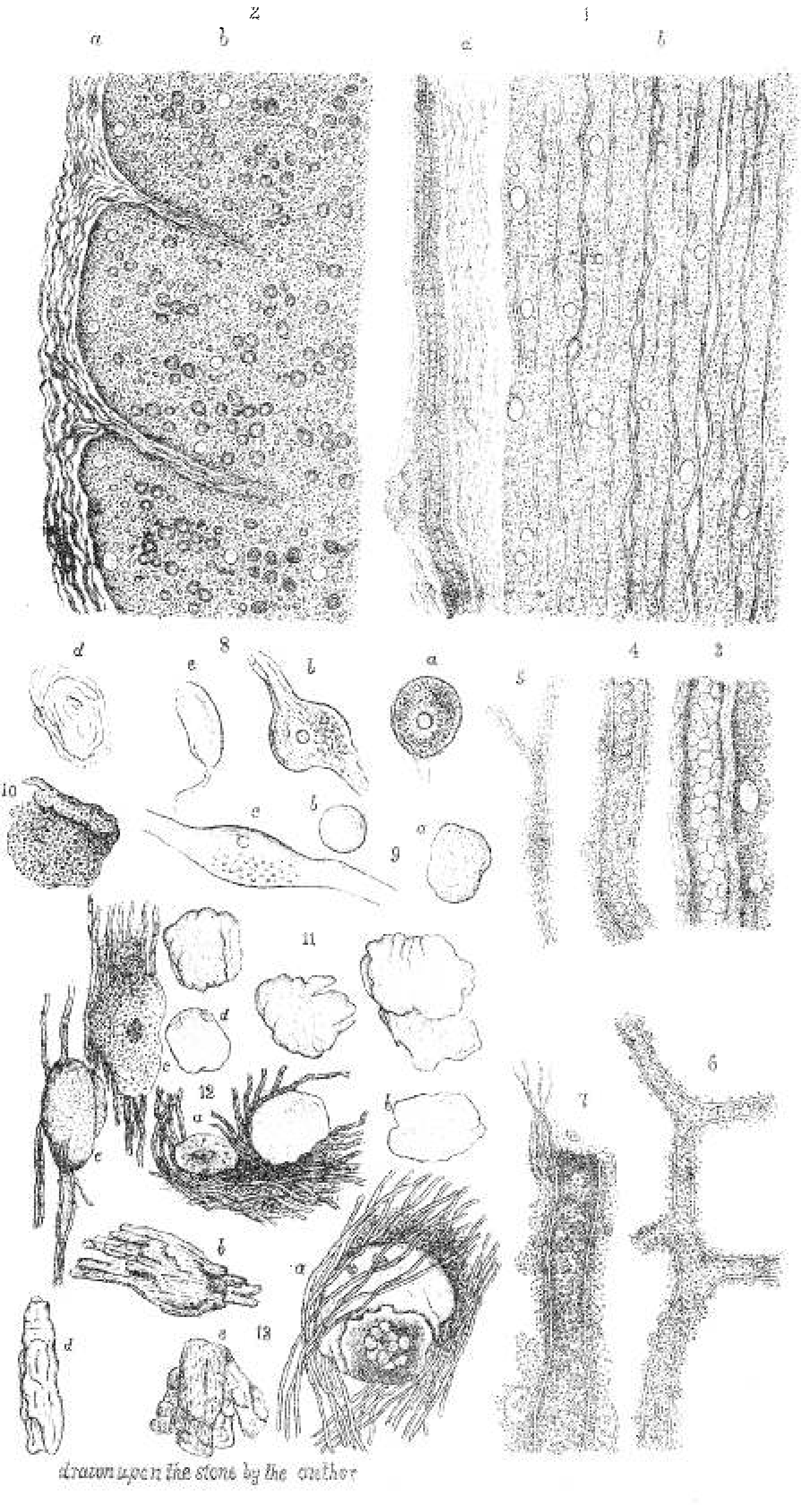
Fig. 10.—Degenerated ganglionic body, treated with iodine.

Fig. 11.—Degenerated ganglionic bodies, of medulla oblongata treated with a 30-per-cent. solution of caustic potassa.

Fig. 12.—Degenerated ganglionic bodies, from the pons Varolii. *a*, two bodies, surrounded by nerve-fibres of the gray substance—one of the bodies still shows the nucleus ; *b*, body, showing its refractive appearance ; *c*, a degenerated body, embedded in a bundle of nerve-fibres, and still showing the nucleus and also its granular nature ; *d*, another body, showing two nuclei ; *e*, a degenerated body, still showing its granules, embedded and connected to dark-bordered nerve-fibres.

Fig. 13.—Crystalline masses met with in the pons Varolii. *a*, a crystalline mass appearing to surround a degenerated blood-vessel, embedded in the gray substance of the pons ; *b*, *c*, and *d*, other crystalline masses, of irregular form, embedded in the bundles of transverse fibres of the pons.

Figures 1 and 2 are magnified about 275 diameters, while the other figures are magnified about 420 diameters.



drawn upon the stone by the author